Biological maturation, relative age and self-regulation in male professional academy soccer players: A test of the underdog hypothesis

Key words: *Soccerl, puberty, adolescence, talent, development*

Introduction

The primary objectives of professional soccer academies are to identify and develop talented youth players (Carling, le Gall, Reilly, & Williams, 2009; Reilly, Williams, Nevill, & Franks, 2000). Early recruitment is the first step in the aforementioned processes (le Gall, Carling, Williams, & Reilly, 2010; Meylan, Cronin, Oliver, & Hughes, 2010) and can be linked to both competitive and financial gains (Reilly, Bangsbo, & Franks, 2000; Vaeyens, Lenoir, Williams, & Philippaerts, 2008). As a consequence, academy players are scouted and recruited at young ages and assessed on the basis of their technical, tactical and physical attributes for the sport.

Individual differences in biological maturation and relative age are related to player selection, evaluation, and performance in youth soccer (Lovell, et al., 2015). Biological maturation refers to progress towards the adult or mature state and can be defined in terms of status, timing and tempo or rate (Malina, Bouchard, & Bar-Or, 2004). Children of the same chronological age vary substantially in status (state of maturation at the time of observation) and timing (chronological age at which specific maturation events occur) of maturity, with some individuals maturing in advance or delay of their peers (Malina, Rogol, Cumming, Silva, & Figueiredo, 2015). A child with a chronological age of 12, for example, could have a biological age anywhere between 9-15 years (Borms, 1986). It should be noted that the process of biological maturation, though related, does not encompass cognitive, emotional, social and/or motor development. Rather, these processes are more closely aligned with age and experience.

Relative age refers to the differences in chronological age that exist among players within a competitive age group and are associated with birth date and cut-off date for the group (Wattie, Cobley, & Baker, 2008). Within a typical one year age band, players can vary in age by up to a maximum of one year (Wattie, Schorer, & Baker, 2015). The relative age effect (RAE) describes a phenomenon whereby those players born early in the selection year are more likely to be represented and succeed in youth sports programmes. RAEs are common across a range of sports, including soccer, and are frequently attributed to the direct and indirect advantages afforded by advanced maturity (Baker, Schorer, & Cobley, 2010; Musch & Grondin, 2001). That is, relatively older players are assumed to be biologically more mature and, thus, physically and functionally superior (i.e., greater size, strength, speed and power) in comparison to their relatively younger peers (Wattie, et al., 2008). While the 'maturational hypothesis' is intuitively appealing, relative age does not necessarily imply more advanced maturity. Whereas relative age is determined by birth and age group cut-off dates, maturation is largely governed by inheritable or genotypic factors (Malina et al., 2004). A child who is the oldest in his age group could, by virtue of their genetic inheritance, also be the least mature player within the group. For similar reasons, the youngest player could also be the most mature.

Research suggests that relative age is, at most, weakly correlated with maturational status in young athletes (Hirose, 2009; Lovell, et al., 2015; Skorski, Skorski, Faude, Hammes, & Meyer, 2016; Whiteley, Johnson, & Farooq, 2017). The independent nature of these constructs is further evidenced in the age at which their respective selection biases emerge and the manner in which these biases change with age (Cumming, Lloyd, Oliver, Eisennnann, & Malina, 2017). In soccer, RAEs can be observed from as early as six years (Helsen, Starkes, & Van Winckel, 1998) and remain stable through late childhood and adolescence (Whiteley, et al., 2017). In contrast, the selection bias towards early maturing boys emerges at approximately 11 to 12 years and increases with age; coinciding with pubertal gains in both size and functional capacity (Malina, 2003; Whiteley, et al., 2017). The presence of the RAE prior to puberty also suggests that this phenomenon is more likely to arise from factors that are more closely aligned with age than maturation, including playing experience, neural, motor, social and/or cognitive development (Blakemore, 2014).

The athletic advantages associated with being relatively older and/or more advanced in maturation are well documented in youth soccer (Whiteley et al., 2017). Relatively younger and/or late maturing players may, however, hold the greatest potential for success at the adult level. Labelled 'the underdog hypothesis' (Gibbs, Jarvis, & Dufur, 2012), this argument was first advanced by Krogman (1950) in the context of little league baseball and then by Gibbs and colleagues in the context of ice hockey. Specifically, the underdog hypothesis contends that to be competitive and/or be retained in youth sports programmes, relatively younger and/or late maturing players must either possess and/or develop superior technical, tactical and psychological skills. That is, comparatively greater challenge is experienced by relatively younger and later maturing players is thought to necessitate and/or encourage the development of these attributes (Gibbs et al., 2012). While superior psychological and/or technical/tactical skills might be masked through childhood and adolescence, they become more salient in late adolescence and early adulthood when age and/or physical maturity are attenuated and/or reversed (Lefevre, Beunen, Steens, Claessens, & Renson, 1990). Further, it can be argued that late maturing players benefit from spending a longer period of time in childhood and adolescence, developmental stages that are optimised for learning and motor skill development (Kirk, 2005). The underdog hypothesis will, however, only be realised if relatively younger and/or later maturing youth are selected into and/or retained within the sport system.

The importance of challenge and the need to possess adaptive psychological and behavioural skills have been long established as requisites for developing excellence in sport (Gould, Dieffenbach, & Moffett, 2002; Orlick & Partington, 1988; Toering, Elferink-Gemser, Jordet, & Visscher, 2009). In support of the underdog hypothesis, a longitudinal study of Swiss elite junior soccer players found that boys delayed in maturation possessed superior adaptive and technical skills (Zuber, Zibung, & Conzelmann, 2016). Despite these advantages, the late maturing players failed to successfully transition to the national or regional talent squads.

Rather, these positions were given to players who were early maturing and athletic, yet less technically and/or psychologically gifted. It should be acknowledged that the methods used to derive biological maturity in this study may impact upon the accuracy of these findings; biological maturity was derived using Mirwald's equation and questions have been raised relative to the validity and reliability of this method (Malina & Koziel, 2014). While some studies have found athletes born late in the competitive year to be equally likely, if not more likely, to be represented at the adult level, an equal number of studies have found the RAE to persist into adulthood (Jones, Lawrence, & Hardy, 2017; Nakata, 2017). Data addressing the maturity status of youth players who persist in soccer at the adult level are limited (Le Gall, Carling, Williams & Reilly, 2010; Malina, Silva, Figueiredo, Carling, & Beunen, 2012; Ostojic, Castagna, Calleja-Gonzalez, Jukic, Idrizovic & Stojanovic, 2014; Figueiredo, Coelho-e-Silva, Sarmento & Malina, under review; Figueiredo, Coelho-e-Silva, Cumming & Malina, under review).

If relatively younger and/or later maturing boys are to be selected or retained in academy soccer then it would benefit them to possess and/or develop more adaptive psychological attributes. Self-regulation refers to processes enabling individuals to control their thoughts, feelings, and actions, including self-initiated processes to convert mental abilities into physical skills in the learning process (Zimmerman, 2006). Individuals who self-regulate also approach tasks with a high level of effort and possess increased levels of self-efficacy in general task situations (Zimmerman, 2006). In youth soccer, self-regulation has been shown to assist effective learning, development potential, and differentiate between successful and less successful players (Toering, Elferink-Gemser, Jordet, & Visscher, 2009). Players who engage in self-regulated learning have been shown to use planning to improve performance, evaluate training outcomes, and reflect upon these processes (Toering, et al., 2009). Whereas planning refers to the establishment of learning objectives and strategies;

evaluation refers to the process of determining whether or not these objectives have been achieved (Toering, Jordet, & Ripegutu, 2013). In contrast, reflection encompasses the consideration of ones strengths and weaknesses and of ways in which they can be developed (Toering et al., 2013). Elite youth soccer players report more adaptive self-regulation than non-elite players, suggesting that self-regulation contributes towards success in this sport (Toering, et al., 2009). Elite players reported engaging in higher levels of reflection and effort, i.e., they appeared more willing to invest effort into task execution and were capable of adapting their knowledge and actions in order to execute skills (Toering, et al., 2009). Failure to engage in self-regulated learning has been shown to negatively impact performance outcomes in sport (Kitsantas & Zimmerman, 2002). With respect to the underdog hypothesis, relatively younger and/or later maturing players may also need to possess and/or develop more adaptive self-regulatory skills if they are to remain competitive within their age groups. At present, however, no research has examined the associations between biological maturation, relative age and self-regulation in young athletes.

In light of the previous discussion, the purpose of this study is to test the underdog hypothesis within the context of academy soccer. It specifically investigates the independent and interactive effects of both relative age and biological maturity status upon self-regulation. Assuming that relatively younger and/or later maturing athletes will possess and/or develop more adaptive self-regulatory skills, it is predicted that relative age and maturation will be inversely associated with self-regulated learning. The study will also explore potential interactions between relative age and maturation upon self-regulation. Specifically, it is predicted that associations between maturation and self-regulation might be accentuated or mitigated by variance in relative age.

Method

Participants*:* Participants were 171 academy soccer players 11–16 years of age from four English professional clubs. Academy soccer players represent a talented and select group who have been identified as having the most potential for success at the adult level. Data collection occurred within the academies during the 2015-2016 season. Players completed assent forms with academy managers acting 'in loco parentis' for players under 18. Parents were informed of the research by the club and asked to provide passive consent (i.e., contact the clubs/researchers if they did not wish their child to participate). Those individuals who did not wish to participate in the study or who were not in attendance or available on the data collection days were not included in the study. Ethical approval was obtained from the host institution's ethical review board for research.

Demographic, anthropometric and psychological data: Demographic and anthropometric data included date of birth, height (cm), weight (kg) and height of biological parents (cm). Academy sports science practitioners trained in the requisite anthropometric dimensions and estimation of maturity status through the Premier Leagues' Elite Player Performance Plan, measured player heights and weights using a standardised protocol. Parent heights were either measured in centimetres by academy staff or self-reported by the parents in feet and inches. Although previous studies show a high correlation between self-reported heights and actual heights (r=.95-.96; Himes & Roche, 1982), self-reported parent heights were adjusted for over-estimation (Epstein, Valoski, Kalarchian, & McCurley, 1995).

Relative Age: Relative age was calculated on the basis of date of birth and the cut-off date for inclusion within a specific age group (August 31st). The difference between these dates was then divided by the number of days within a year and expressed as a decimal. Relative age was thus expressed as value between 0 and .99 year with the values representing the youngest and oldest players, respectively, within an age group. Relative age was also classified into birth quartiles to allow readers to compare the RAE observed in the current study with those presented in previous literature (Q1 = September, October and November, Q2 = December, January and February, Q3 = March, April and May and Q4 = June, July, August).

Maturity status: Percentage of predicted adult height (PPAH) at the date of assessment was used as the indicator of maturity status. This method assumes that players who are closer to their adult stature for their age are more advanced in somatic maturity status. A 12 year old boy who has attained 85% of his predicted adult height, for example, would be considered more mature than a boy of the same age who has attained 75% of his predicted mature height. Adult height was predicted with the method of Khamis and Roche (Khamis & Roche, 1994) based on a middle class sample of Ohio children in the United States. The prediction equation requires the current age, height and weight of the player, and the mean height of his biological parents (mid-parent height). The median error bound between actual and predicted mature height is 2.2 cm in males between the ages of 4 and 17.5 years (Khamis & Roche, 1994). Maturity status was then expressed as a z-score relative to age and sex specific reference values based on a longitudinal series of boys from the Berkeley Growth Study (Bayer & Bailey, 1959). The Khamis-Roche (KR) method has demonstrated concurrent and predictive validity in samples of US, British and Portuguese youth (Cumming, Battista, Standage, Ewing, & Malina, 2006; Cumming, Sherar, Esliger, Riddoch, & Malina, 2014; Malina, Morano, Barron, Miller, & Cumming, 2005; Malina, et al., 2006; Sweet, Dompier, Stoneberg, & Ragan, 2002) and has been validated relative to an established indicator of maturity status (skeletal age) in American youth soccer players (Malina, Dompier, Powell, Barron, & Moore, 2007) and Portuguese soccer players (Malina, Silva, Figueiredo, Carling, & Beunen, 2012).

Psychological data: Participants were presented with a questionnaire that included some demographic questions (e.g., date of birth, age group) and a copy of the Football-specific self-regulated learning questionnaire (FSSRLQ). Participants received a brief introduction to the questionnaire and were guided through an example question to ensure full clarification. Where data were missing (.003% of items), mean item replacement was used. This method has been shown to be a good representation of the original data, and mean item replacement is a legitimate method with proven reliability (Downey & King, 1998).

Football-specific self-regulated learning questionnaire (FSSRLQ): The FSSRLQ (Toering et al., 2013) is a psychometric instrument that assesses self-regulated learning in elite soccer players, aged 13 years and older. It consists of 22 items representing three sub-scales, planning (example item: I have a clear goal for each practice session), evaluation (example item: After each practice session I think back and evaluate whether I did the right things to reach my practice goal) and reflection (example item: During each practice session I check whether I make progress in my football skills), and a composite score for adaptive self-regulation. The FSSRLQ had adequate reliability and validity within a sample of elite Dutch youth soccer players (123 boys, 81 girls) aged 13–16 years (Toering, et al., 2013). The items on the planning subscale were developed from the self-regulatory inventory designed by Hong and O'Neil Jr. (2001) and were scored on a 4-point Likert rating scale anchored by (1) *almost never* to (4) *almost always*. The subscales of evaluation (6 items) and reflection (9 items) were scored on a 5-point Likert rating scale. In accordance with the original scales, evaluation ranged from (1) *never* to (5) *always*, and reflections ranged from (1) *strongly agree* to (5) *strongly disagree*. Before data analysis, reflection scores were reversed to make them correspond to the scores on the other subscales. The mean item score for each subscale was calculated for each participant. The scale showed acceptable internal consistency in the current sample of youth soccer players (Cronbach's alphas = reflection =0.86, evaluation =0.81, planning =0.74). The overall consistency of the scale was also high (Cronbach alpha = .91), indicating strong internal consistency.

Statistical analysis: Descriptive statistics were calculated for the variables of interest. Pearson product moment correlations were calculated for the following variables: estimated maturity status, percentage of predicted adult height, relative age, height, weight, chronological age, self-regulation, reflection, evaluation and planning. Hierarchical regression analysis was used, controlling for whole year age (i.e., participant's age in single year units at point of assessment), to evaluate the main and interactive effects of relative age and maturity status upon overall self-regulation across the three subscales. Centring the variables of interest and then multiplying the centred values produced an interaction term for relative age and maturity status. SPSS (IBM SPSS 22) was used for all analyses. At the request of the reviewers and on the recommendation of the editor, partial correlations were conducted to estimate the effect sizes associated with statistically significant associations.

Results

Descriptives Statistics: The descriptive statistics for estimated biological maturity, predicted adult height, relative age, height, weight, and self-regulation, including reflection, planning and evaluation are presented in *Table 1*. Mean values for height, weight and maturity increased across the age groups. The mean value for relative age was above .50 years in all age groups and did not appear to increase or decrease with age. Among the total sample of 171 participants, 47% were born in Q1, 27% in Q2, 17% in Q3, and 9% in Q4.

Correlational Analysis: Correlations among the variables of interest are summarized in *Table 2*. Advanced maturation was positively and strongly associated with height and weight, while delayed maturation was associated with greater self-regulation, planning, reflection and evaluation. Relative age was unrelated to biological maturity status, self-regulation, planning and evaluation, yet was positively associated with reflection. Relative age was positively correlated with height and weight, though the magnitude of the correlations was small.

Regression Analysis: *Table 3* presents a 3-step hierarchical regression model predicting self-regulation, whereby 'age' is entered at Step 1 (Model 1), biological maturation and relative age are added at Step 2 (Model 2), and the interaction between biological maturity and relative age is added at Step 3 (Model 3). The final regression model for self-regulation was statistically significant, $F\ (3,167) = 3.41,\ p < .05,$ explaining three percent of the variance in self-regulation. Adjusted correlations were conducted to determine the magnitude of statistically significant main and interactive effects. The main and interaction effects revealed a statistically significant main effect for biological maturation upon self-regulation. Specifically, later maturation was associated with higher self-regulation scores. The magnitude of this association was, however, small (*adjusted* $r = .17$). Age, relative age, and the interaction between maturation and relative age did not predict self-regulation.

Regression models were also conducted for the three self-regulation subscales (Tables 4, 5, & 6). The final regression model predicting planning was statistically non-significant, $F\ (3,167) = 1.86,\ p > .05$, however, the models for evaluation, $F(3,167) = 3.05,\ p < .05$, and reflection, $F(3,167) = 5.39,\ p < .05$, achieved statistical significance, explaining two and five percent of the variance in their respective subscales.. Closer inspection of the main and interactive effects for the latter models revealed later maturation to be predictive of greater engagement in reflection and evaluation, though the magnitude of these associations was small (*evaluation: adjusted* $r = .16$; *reflection: adjusted* $r = .21$). Age, relative age, and the interaction between relative age and maturation, did not serve as significant predictors of reflection and evaluation.

Discussion

This is the first study to examine relations among relative age, biological maturity status and self-regulation in English professional academy soccer players. Consistent with previous research, a RAE and bias towards selecting players advanced in maturation was observed in the distributions of players within specific age groups. The RAE was present before 12 years and was stable with age. The selection bias for early maturing players was comparatively small in the youngest age groups (U12, U13) yet, as with previous research, demonstrated an increasing trend with age. Of note, relative age was unrelated to maturity status in the current sample; by inference, older age within an age group did not imply more advanced maturity. These findings fail to support the maturation hypothesis, in which the RAE is viewed as resulting from differences in biological maturity status (Baker, Janning, Wong, Cobley & Schorer, 2014). Rather, they suggest that relative age and maturity selection biases exist and operate independently in English academy soccer.

In support of the underdog hypothesis, later maturing players reported more adaptive engagement in self-regulated learning, in particular self-evaluation and reflection. More adaptive learning skills may help mitigate some of the physical and functional disadvantages associated with later maturation (e.g., smaller size, inferior strength, speed, power. Malina et al., 2015). They may also provide an athletic advantage in adulthood, when maturity associated differences in size and function have attenuated or, in some cases, reversed (Lefevre et al., 1990). This advantage will only be realized, however, if later maturing players are selected into and retained within the academy system. Whether late maturing players possess a more adaptive skill set out of necessity (i.e., late maturing players without these skills are not selected or retained in the system) or whether these abilities develop as a response to greater challenge is, as of yet, unclear. Though statistically significant, it is important to note that the associations between maturation and self-regulation were small in magnitude. A marginally more adaptive self-regulation profile, though desirable in the long term, may not be sufficient to offset the physical disadvantages associated with later maturation and/or guarantee progression to the most senior levels. In support of this contention, Zuber et al., (2016) found that late maturing Swiss soccer players, despite being psychologically and technically more gifted, were underrepresented and failed to enter the most elite level programs (Zuber et al., 2016). Thus, further strategies may required to ensure that talented, yet less mature, academy players are are not overlooked to excluded from the academy systems.

Relative age and the interaction between relative age and biological maturity status did not predict engagement in self-regulatory learning in academy soccer players. This suggests that relative age does not contribute towards an underdog effect in this specific context, at least with respect to self-regulation and the current sample. It should be noted, however, that the players in the current study represent a highly select group of adolescent athletes. Differences in relative age may exert greater influence upon self-regulated behavior in childhood and/or at the grassroots level. Younger relative age may still afford an underdog advantage in attributes not included in this study; including motivation, decision making, resiliency, and/or technical and tactical ability. Future research may wish to consider studying the underdog effect in relation to these constructs.

The present study's findings have important implications for the selection and development of young soccer players. As relative age and maturation biases exist and operate independent of one another, practitioners should design separate strategies to address their respective biases. Ideally, these strategies should also be implemented at different levels and stages of athlete development. Strategies designed to combat RAEs should be introduced to combat maturity selection biases and are best delivered at the onset of adolescence, when maturity associated differences in size and function first emerge, and within an academy context. The results of the current study suggest that underdog effects in soccer may be more likely to result from variance in maturation than relative age. This observation may be explained by a greater potential for variance in maturation than relative age within competitive age groups. Players of the same chronological age have been shown to vary by as much as 5 to 6 years in skeletal age. In contrast, the maximum potential for variance in relative age within a competitive age group is 0.99 years. Accordingly, the least mature players within an age group may have a greater need to possess superior technical/tactical or psycho-behavioral skills than those who are the youngest. In line with this reasoning, Whitely et al., (2017) found maturation to exert a much greater impact upon player selection and retention in academy soccer than relative age.

While it is valuable to highlight the potential benefits of later maturation in soccer, it is equally important to consider and address any possible disadvantages associated with early maturity. Pressures to succeed and/or avoid being released may encourage early maturing players to rely on their physical and functional advantages at the expense of their psychological and technical/tactical development. Due to the transient nature of physical and athletic advantages, early maturing players will also be unable able to rely upon these attributes at the adult level. It is therefore imperative that academies create learning environments that encourage early maturing boys to develop the more adaptive skill sets and not to rely on their physicality. Strategies such as bio-banding (Cumming, Lloyd, Oliver, Eisenmann, & Malina, 2017), in which players are periodically grouped by maturity status rather than chronological age, have been shown to expose early maturing males to greater challenge and to provide the same learning conditions that late maturing players experience on a regular basis (Cumming, Brown, et al., 2017; Reeves, Enright, Dorling, & Roberts, 2018). When competing in bio-banded formats, early maturing males report being less able to rely on their physical and functional attributes and are forced to use their technical, tactical and psychological skills. Further, early maturing players also benefit from playing with, and being mentored by, older peers. Sports psychologists can support early maturing boys in such contexts by aligning their psychological provision; teaching early maturing players how to use more adaptive self-regulatory skillsets, optimising their physical, psychological, technical and tactical development.

Although later maturing players reported greater engagement in self-regulation, a selection bias towards players advanced in maturity was still evident in the current sample. This suggests that adaptive psychological skills, while desirable, may not be sufficient to overcome the physical and functional disadvantages associated with later biological maturation. By limiting maturity-associated variation in size and function, bio-banding affords late maturing players greater opportunity to use and demonstrate their technical, physical and psychological attributes. Moreover, evidence suggests that bio-banding as a grouping strategy encourages a less physical and more technical and tactical style of play (Cumming, Brown, et al., 2017). A recent comparison of technical and physical performance across bio-banded and age grouping strategies revealed twice as much passing and dribbling in the maturity-matched format (Thomas, Oliver, Kelly, & Knapman, 2017). Bio-banding also provides coaches, scouts and academy managers with the opportunity to evaluate early and later maturing players in scenarios where maturity-associated differences in size and function are less pronounced, making differences in psychological, technical and tactical ability more detectable. Strategies such as average age teams and relative age and/or maturity ordered numbered bibs may also help coaches and scouts better recognise and account for differences associated with variation in maturity status and relative age when evaluating player performance (Mann & van Ginneken, 2017).

The present study is not without its limitations. First, measures of parent height were either measured directly or self-reported. While measures of true parental height are ideal, the latter method relies on accurate self-reporting and the associated adjustment equations for overestimation. Differences in physical size (i.e., height and weight) may have played an additional role in relation to the selection and/or development of players with specific psychological profiles. For example, self-regulation may be equally important for boys who are constitutionally small yet early maturing. As noted, the cross-sectional nature of this study also makes it difficult to ascertain whether later maturing players had always possessed a more adaptive self-regulatory skills set or if it developed as a result of the greater challenges that they had faced. Future studies should employ longitudinal designs to better understand how self-regulatory skills develop and the role that they play in relation to the processes of selection and retention. Finally, it should be noted that this study assessed only one aspect of the players' maturational status (i.e., physical) and that cognitive, social, and/or motor development are more closely associated with age than biological maturity.

In conclusion, the results of the present study partially support the underdog hypothesis. Although an apparent selection bias towards relatively older players was found, the results indicated no association between relative age and self-regulation. In contrast, later maturing players appeared to possess a psychological advantage as evidenced in greater self-regulation, specifically self-evaluation and reflection. This study is the first of its kind in youth soccer and, thus, the results must be considered and interpreted with caution. Further research is required. Nevertheless, the results of the current study highlight the importance of retaining late maturing players within academy systems and challenging players who are advanced in maturation.

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